CLAIMS

What is claimed is:

1. A method of making an elongated carbide nanostructure, comprising the steps of:

a. applying a plurality of spatially-separated catalyst particles to a substrate;

b. exposing the spatially-separated catalyst particles and at least a portion of the substrate to a metal-containing vapor at a preselected temperature and for a period sufficient to cause an inorganic nano-structure, including the metal, to form between the substrate and at least one of the catalyst particles; and

c. exposing the inorganic nano-structure to a carbon-containing vapor source at a preselected temperature and for a period sufficient to carburize the inorganic nano-structure, thereby creating an elongated carbide nanostructure.

2. The method of Claim 1, further comprising the step of removing a plurality of catalyst particles from the elongated carbide nano-structure.

3. The method of Claim 2, wherein the removing step employs etching.

4. The method of Claim 1, wherein the inorganic substrate includes a material selected from a group comprising: an oxide; a metal; or an elemental semiconductor, and combinations thereof.

5. The method of Claim 1, wherein the carbon-containing vapor source is a gas selected from a group comprising: methane, ethylene ethane, propane, and isopropylene, and combinations thereof.

6. The method of Claim 1, wherein the inorganic nano-structure is also exposed to hydrogen gas while being exposed to the carbon-containing vapor source.

7. The method of Claim 1, wherein the step of applying a plurality of spatially-separated catalyst particles comprises the steps of:

a. applying a thin film of the catalyst to the substrate; and

b. heating the thin film to a temperature sufficient to cause the catalyst to enter a liquid phase, thereby causing the catalyst to agglomerate so as to form spatially-separated particles.

8. The method of Claim 7, wherein the thin film has a thickness of between 3 nm and 10 nm.

9. The method of Claim 7, wherein the thin film is applied to the substrate by electron beam evaporation.

10. The method of Claim 7, wherein the thin film is applied to the substrate by sputtering.

11. The method of Claim 1, further comprising the step of flowing a reducing gas during the carburization process.

12. The method of Claim 11, wherein the reducing gas comprises hydrogen.

13. The method of Claim 1, wherein the step of applying a plurality of spatially-separated catalyst particles comprises the step of depositing the catalyst particles within a porous template.

14. The method of Claim 13, wherein the porous template comprises anodized aluminum oxide.

15. The method of Claim 13, wherein the porous template comprises silicon dioxide.

16. The method of Claim 1, wherein the step of applying a plurality of spatially-separated catalyst particles comprises the steps of:

a. suspending a plurality of nano-particles of the catalyst in an organic solvent;

b. applying nano-particles and the solvent to the substrate; and

c. dispersing the nano-particles with a spin coater.

17. The method of Claim 16, further comprising the step of adding a surfactant to the organic solvent and the nano-particles so as to inhibit agglomeration of the nano-particles.

18. The method of Claim 16, wherein the solvent comprises alcohol.

19. The method of Claim 16, wherein the solvent comprises acetone.

20. The method of Claim 1, wherein the catalyst is selected from a group comprising: gold, nickel, iron, cobalt or gallium, and combinations thereof.

21. The method of Claim 1, further comprising the step of applying an electrically conductive buffer layer to the substrate prior to the step of applying a plurality of spatially-separated catalyst particles to the substrate, wherein the buffer layer acts as a diffusion barrier.

22. The method of Claim 21, wherein the buffer layer is a material selected from a group comprising: germanium carbide tungsten, silicon carbide or titanium tungsten, and combinations thereof.

23. The method of Claim 21, wherein the step of applying an electrically conductive buffer layer employs an epitaxial process.

24. The method of Claim 1, further comprising the step of applying an electrical field to the spatially-separated catalyst particles and at least a portion of the substrate while exposed to the metal-containing vapor, thereby influencing direction of growth of the inorganic nano-structure.

25. A method of making a field emission device, comprising the steps of:

a. applying a dielectric layer to a substrate;

b. applying a conductive layer to the dielectric layer, opposite the substrate;

c. forming at least one cavity in the conductive layer and the dielectric layer, thereby exposing the substrate; and

d. growing at least one nanorod in the cavity.

26. The method of Claim 25, wherein the step of growing at least one nanorod comprises:

a. applying at least one catalyst particle within the cavity;

b. exposing the catalyst particle and at least a portion of the substrate to a metal vapor and an oxidizing gas at a preselected temperature and for a period sufficient to cause an oxide nanorod, including an oxide of the metal, to form between the substrate and the catalyst particle;

c. exposing the oxide nanorod to a carbon-containing vapor source at a preselected temperature and for a period sufficient to carburize the oxide nanorod; and

d. removing the catalyst particle.

27. The method of Claim 26, wherein the step of applying at least one catalyst particle includes the step of applying a patterned catalyst film within the device cavity.

28. The method of Claim 26, wherein the removing step is performed by etching.

29. The method of Claim 25, further comprising the step of forming a conductive platform on the substrate and within the cavity, wherein the step of

growing at least one nanorod in the cavity comprises growing the nanorod from the conductive platform.

30. A field emission device, comprising

a. a substrate having a top side and an opposite bottom side;

b. a dielectric layer disposed on the top side;

c. a conductive layer disposed on top of the dielectric layer opposite the substrate, the conductive layer and the dielectric layer defining a cavity extending downwardly to the substrate; and

d. at least one nanorod affixed to the substrate and substantially disposed within the cavity.

31. The field emission device of Claim 30, further comprising a buffer layer affixed to the top side of the substrate.

32. The field emission device of Claim 30, employed in an imaging system.

33. The field emission device of Claim 30, employed in a lighting system.

34. The field emission device of Claim 30, wherein the nanorod is an X-nanorod, wherein X is a material selected from a group comprising: a carbide, an oxide, a nitride, an oxynitride, an oxycarbide or a silicide, and combinations thereof.

35. The field emission device of Claim 30, wherein the substrate comprises an inorganic monocrystalline substance.

36. The field emission device of Claim 35, wherein the inorganic monocrystalline substance comprises a material selected from a group comprising: silicon, an aluminum oxide, and silicon carbide, and combinations thereof.

37. The field emission device of Claim 30, wherein the dielectric layer comprises a material selected from a group comprising: silicon dioxide, silicon nitride, silicon oxynitride, and aluminum oxide, and combinations thereof.

38. A nanostructure, comprising:

a. an inorganic substrate having a top side and a bottom side;

b. a conductive buffer layer disposed adjacent to the top side; and

c. a plurality of elongated carburized metal nanostructures extending from the conductive buffer layer.

39. The nanostructure of Claim 38, wherein the inorganic substrate comprises is a crystalline substance, selected from a group consisting of: silicon, aluminum oxide, and silicon carbide, and combinations thereof.

40. The nanostructure of Claim 38, wherein the plurality of elongated carburized metal nanostructures comprises at least one nanorod.

41. The nanostructure of Claim 38, wherein the plurality of elongated carburized metal nanostructures comprises at least one nanoribbon.

42. The nanostructure of Claim 38, wherein the plurality of elongated carburized metal nanostructures each has a smaller dimension of less than 800 nm.

43. The nanostructure of Claim 38, wherein the carburized metal is carburized from an oxide of a metal selected from a group comprising: molybdenum, niobium, hafnium, silicon, tungsten, titanium, or zirconium, and combinations thereof.

44. A field emission device, comprising

a. a substrate having a top side and an opposite bottom side;

b. a dielectric layer disposed on the top side;

c. a conductive layer disposed on top of the dielectric layer opposite the substrate, the conductive layer and the dielectric layer defining a cavity extending downwardly to the substrate;

d. a conductive platform, having a top surface, disposed on the top side of the substrate within the cavity; and

e. at least one nanorod affixed to the top surface of the conductive platform and substantially disposed within the cavity.

45. The field emission device of Claim 44, wherein the conductive platform comprises a conic-shaped member having a relatively large bottom surface opposite the top surface, the bottom surface affixed to the substrate.

46. The field emission device of Claim 44, wherein the conductive platform comprises a material selected from a group comprising: silicon, molybdenum, platinum, palladium, tantalum, or niobium, and combinations thereof.

47. The field emission device of Claim 44, wherein the nanorod is a carbide nanorod.

48. The field emission device of Claim 44, wherein the substrate comprises an inorganic monocrystalline substance.

49. The field emission device of Claim 48, wherein the inorganic monocrystalline substance is selected from a group comprising: silicon, aluminum oxide and silicon carbide, and combinations thereof.

50. The field emission device of Claim 44, wherein the substrate comprises a polycrystalline material.

51. The field emission device of Claim 44, wherein the substrate comprises amorphous glass.

52. The field emission device of Claim 44, wherein the dielectric layer comprises silicon dioxide.

53. A structure including a polycrystalline nanorod comprising a material selected from the group comprising: molybdenum carbide, molybdenum silicide, molybdenum oxycarbide, or niobium carbide.